A Preliminary Evaluation of Measuring Future Routing Initiatives

Southern Region Case Study

Presented by
Dan Citrenbaum (daniel.citrenbaum@faa.gov)
Dave Chien, Ph.D. (david.chien@faa.gov)
Doug Baart (douglas.baart@faa.gov)
Federal Aviation Administration
ASD-400, Investment Analysis & Operations Research

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Overview

- Background
- Objectives
- Methodology
- Results
- Conclusions

Background

- Initial study evaluated in 1996 by ASD-400 that examined several performance metrics in the Southern Region for a day in 1995
- The air traffic environment from 1996 to present has changed:
  - 20 percent more air traffic operations through ZJX, ZMA, and ZTL
  - Flight times have increased 7-10 percent throughout the NAS
  - Area Navigation (RNAV) initiatives have accelerated
  - Domestic RVSM (DRVSM) is planned for implementation by 2005
  - Free Flight Program has evolved
- Number of flights participating in the North American Route Program (NRP) has remained steady in the recent years
  - Approximately 3 percent of the flights that file flight plans file NRP; 5 percent of scheduled commercial flights file NRP

Objectives

- To provide summary metrics that identify differences in a range of potential routing scenarios

  Metrics include:

  - Fuelburn
  - Flight distance
  - Flight time
  - Proximity alerts (conflicts)
  - Operational delay
- To apply a framework that measures the potential "pool of benefits" of increased utilization expected from planned en route NAS initiatives
- To assess some of the efficiency initiatives in the Operational Evolution Plan (OEP) and NAS Architecture
- To apply multiple sets of data sets, tools, and models to a practical "real-world" problem

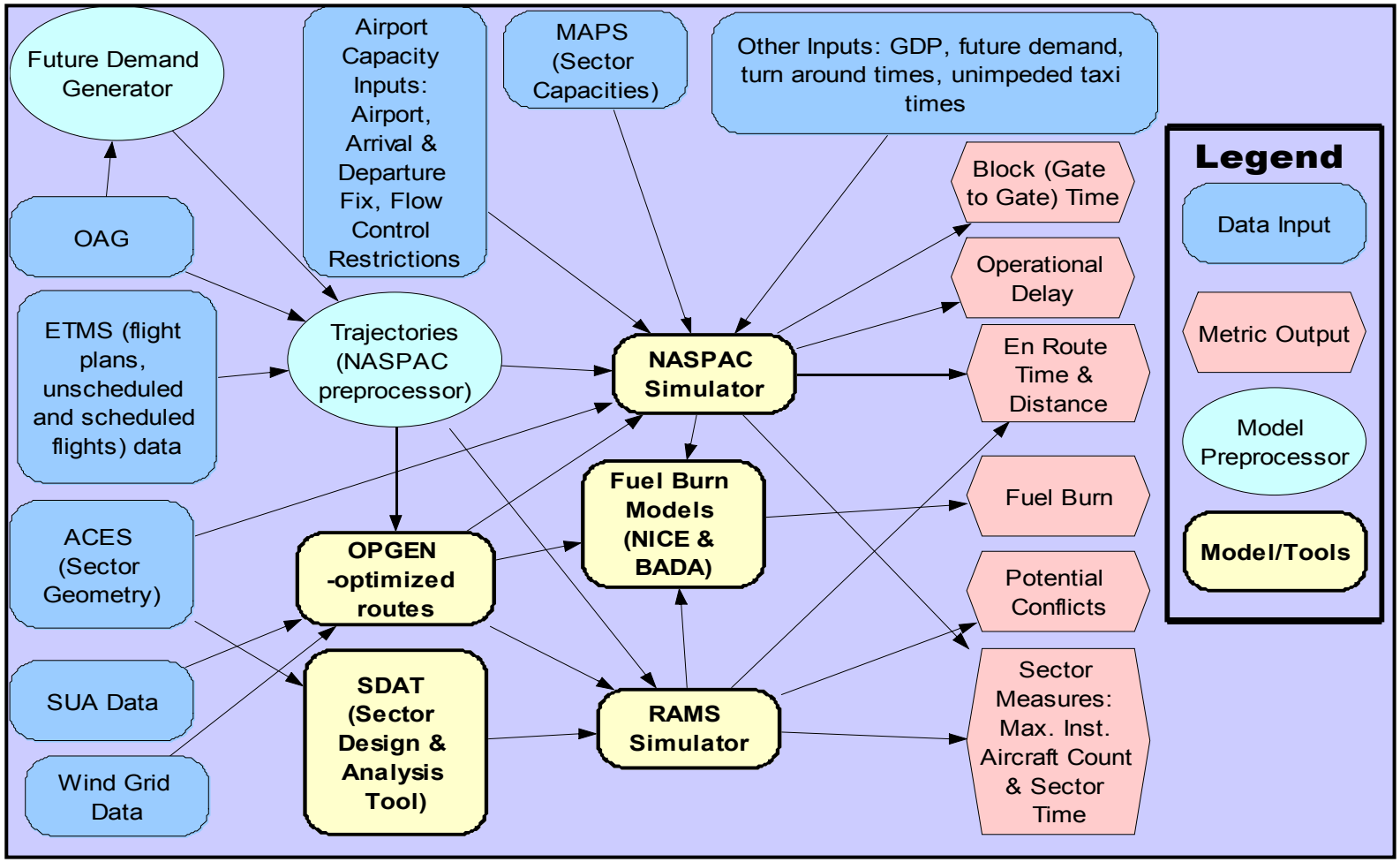
Methodology

Overview of Primary Tools and Models

Tools and Models	Description
Reorganized Air Traffic Mathematical Simulator (RAMS)	A discrete-event simulation model developed by Eurocontrol. It is used for the study of airspace design, ATC systems, and future ATC concepts. It is typically used for *regional analysis.*
NAS Performance Analysis Capability (NASPAC)	A discrete-event simulation model that tracks aircraft as they progress through the NAS. It measures system performance based on demand placed on the airspace and airports. It is typically used for *national analysis.*
Sector Design & Analysis Tool (SDAT)	A decision support tool that provides *NAS sector geometries* that are input into RAMS
Optimal Trajectory Generator (OPGEN) Model	A model that attempts to fly an *optimum trajectory* using wind-optimized routes from both the original flight plan and other flight plan variations, e.g., future demand, given a set of pre-established criteria
The North Atlantic Systems Implementation Group Cost Effectiveness Programme (NICE) Fuelburn Model	An ICAO-endorsed model that provides *fuel consumption* rates for specified aircraft type by speed, altitude (climb, cruise, and descent), and weight of aircraft. The information is provided by Lufthansa Airlines.
Aircraft Performance Summary Tables for Base of Aircraft Data (BADA)	Provides performance tables of *fuel consumption* based on a total-energy model and performance coefficients for 67 aircraft types. The information is provided by Eurocontrol.

Methodology (Cont'd)

Interrelationships between Tools and Models



Methodology (Cont'd)

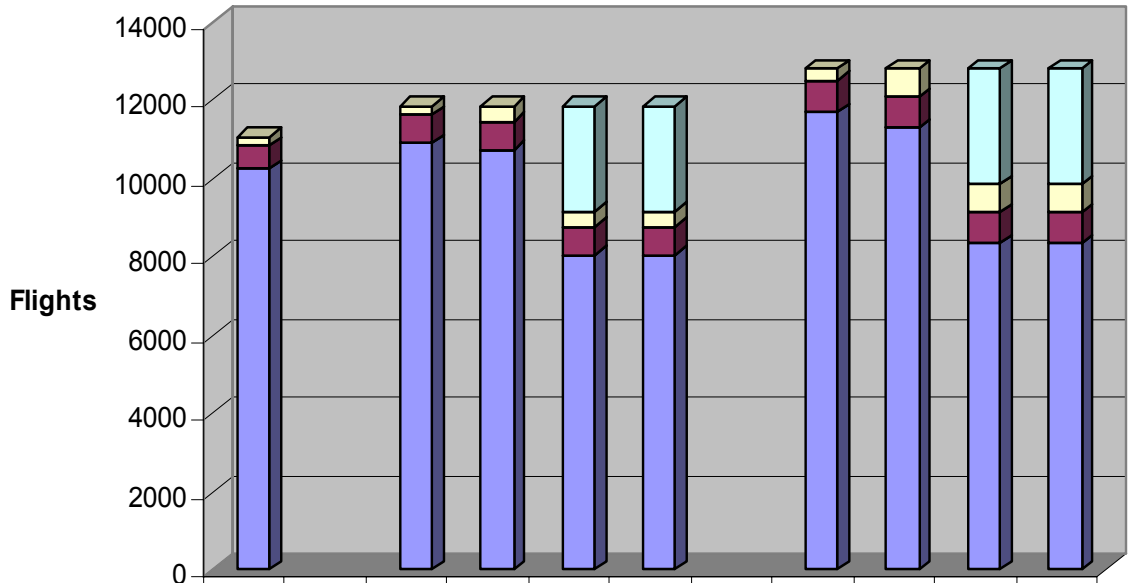
Overview of Cases

Case*	2000	2005	2010	2015	Key Elements
Case 1: Baseline	X				Current NRP and Southern Region RNAV routes
Case 2: Baseline + ***Increased RNAV Routes***		X	X	X	Projected growth in Southern Region RNAV routes
Case 3: Baseline + Increased RNAV Routes + ***Increased Wind Optimized Routes***		X	X	X	Additional wind optimized routes for FL290 and above and stage length >=750 nmi
Case 4: Baseline + Increased RNAV Routes + Increased Wind Optimized Routes + ***Domestic RVSM***		X	X	X	Reduction in vertical separation from 2000' to 1000' from FL290 to FL390

* Each case is additive and reflects enhanced capabilities

Methodology (Cont'd)

Distribution of Flights through Southern Region



	2000 Base		2005 Base	2005 NRP &	2005 Wind Opt.	2005 RVSM		2010 Base	2010 NRP &	2010 Wind Opt.	2010 RVSM
Wind Opt. Route					2692	2692				2954	2954
RNAV Route	229		256	421	421	421		287	713	713	713
NRP Route	618		722	722	722	722		818	818	818	818
Pref. Route	10235		10892	10727	8035	8035		11708	11282	8328	8328

Note: In 2005, there were 5976 flights that flew the Southern Region which were candidates for RVSM. RVSM equipped aircraft types by carrier were provided by the FAA.

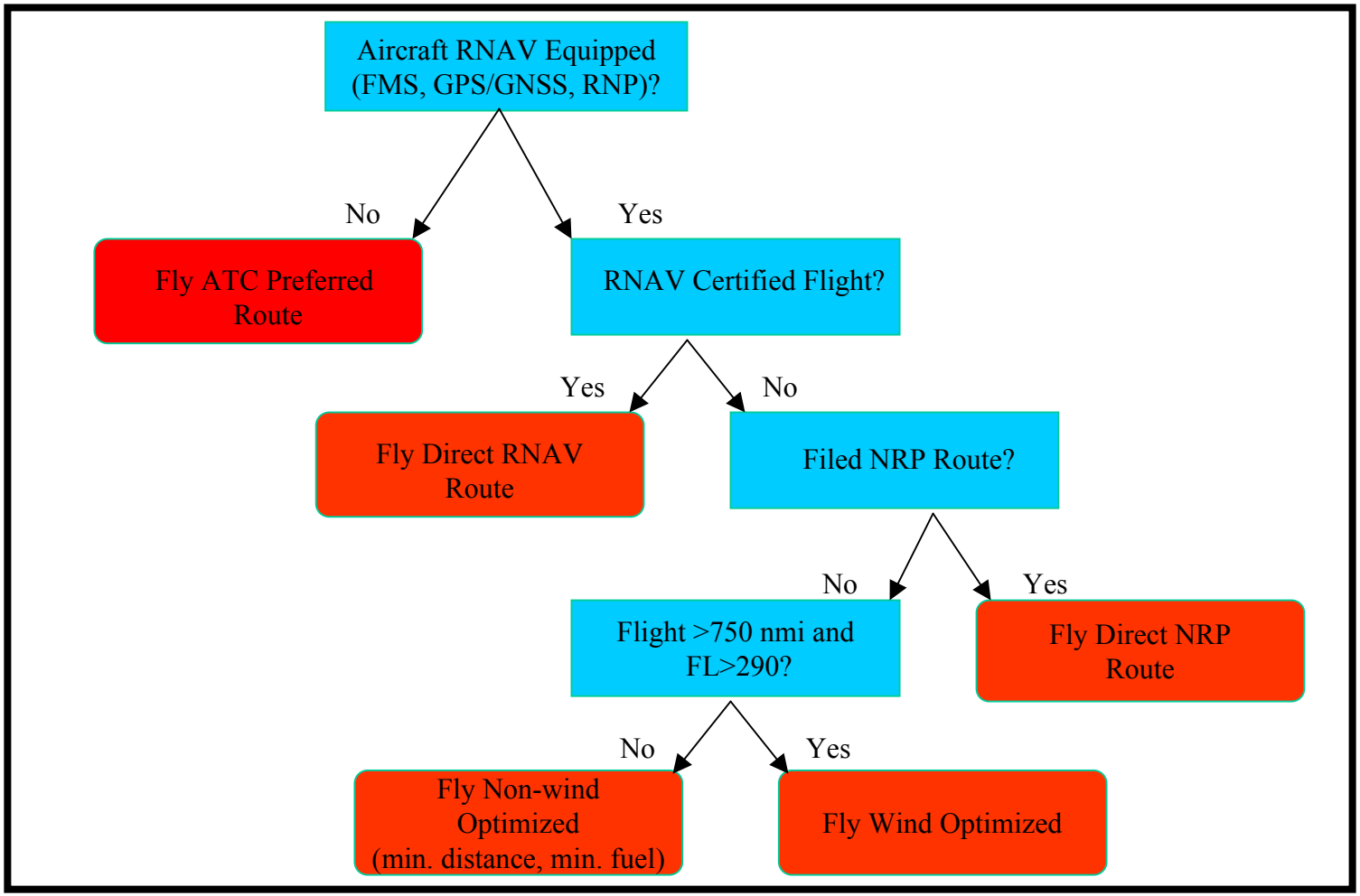
Methodology (Cont'd)

Type of Equipment Eligible to Fly RNAV Routes

Aircraft Equipment Suffix	Description
/E	Flight Management System (FMS) with en route capability. Equipment requirements are a) dual FMS which meets the specifications of AC Management Systems in Transport Category of Airplane, b) a flight director and autopilot control system capable of following the lateral and vertical FMS flight path, c) a least dual inertial reference units, and d) a database containing the waypoints for the speed/altitude constraints for the route and/or procedure to be flown that is automatically loaded into the FMS flight plan.
/F	A single FMS with en route, terminal, and approach capability that meets the equipment requirements of /E, a through d
/G	GPS/GNSS equipped aircraft with en route and terminal capability
/I	LORAN, VOR/DME or INS, transponder with Mode C
/R	Required Navigation Performance (denotes capability to operate in RNP designated airspace and routes)

These five codes comprise 57 percent of the aircraft that filed IFR flight plans on 8/28/2000.

Methodology (Cont'd)
Route Selection Process

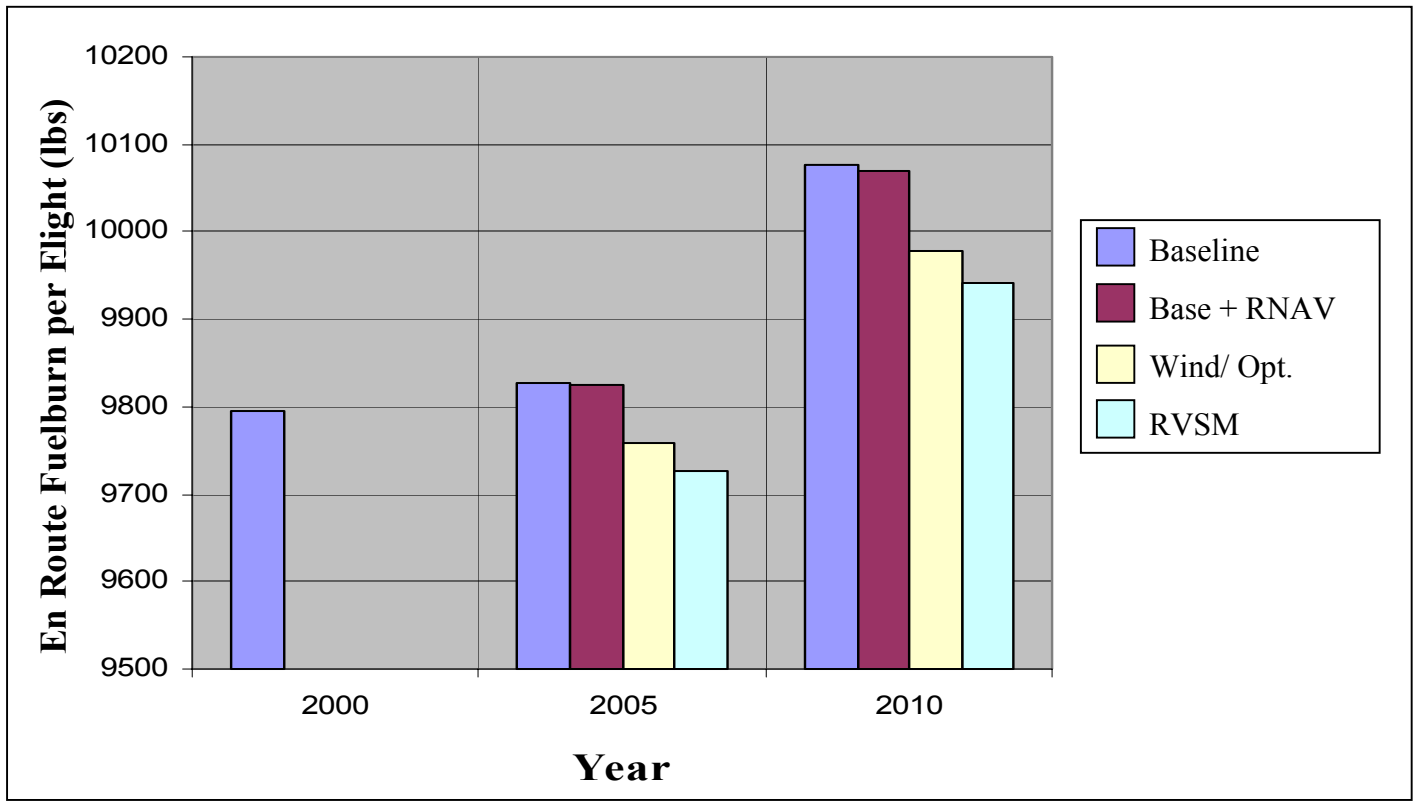


Methodology (Cont'd)
DRVSM (Case 4)

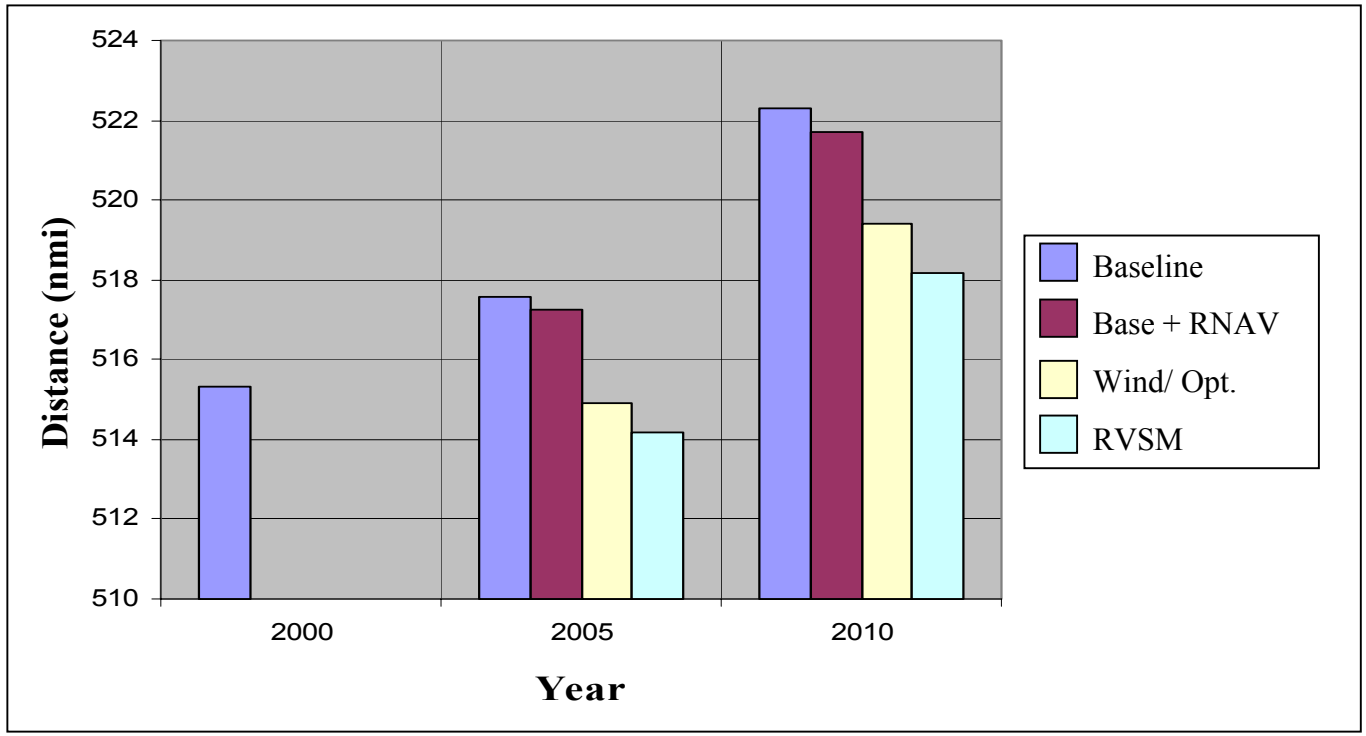
- Altitude allocation per ATC 7110.65
- 0-179 degree heading gives odd cardinal flight level of FL290, 330, and 370
- 180-359 degree heading gives odd cardinal flight level of FL310, 350, and 390
- Vertical separation currently 2000 feet; horizontal separation minima is 5 nautical miles
- Current and future RVSM equipage by carrier/aircraft type provided by FAA's Flight Standards Division
- Optimistic assumption that RVSM will be completed by 2005 for FL290-410
  - Upper altitude is the first priority when changing flight level, i.e., when an aircraft is at FL350 it will attempt to go to FL360 before FL340

Preliminary Results

Results
Average Fuel Consumption



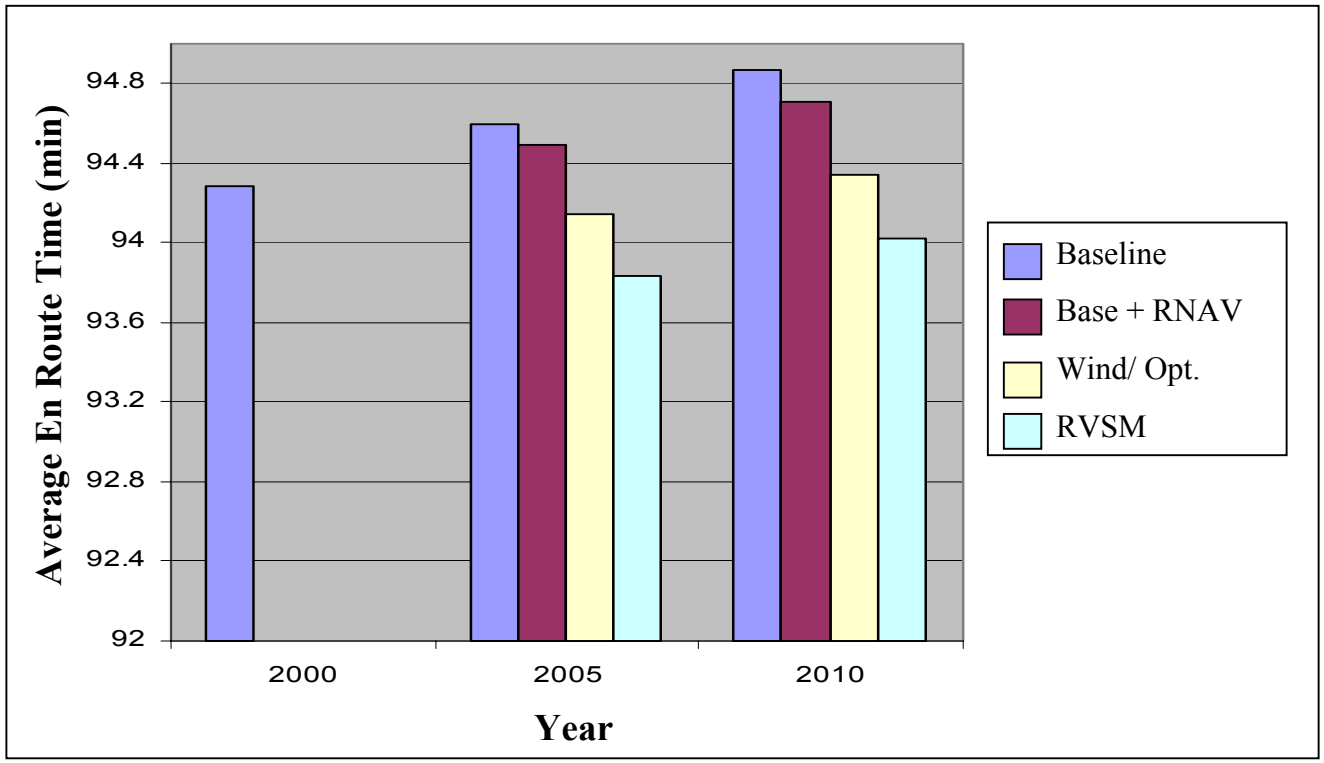
Results (Cont'd)
Distance



An average of 3-4 miles per flight was saved for the wind optimized and RVSM cases in 2005 and 2010.

Results (Cont'd)

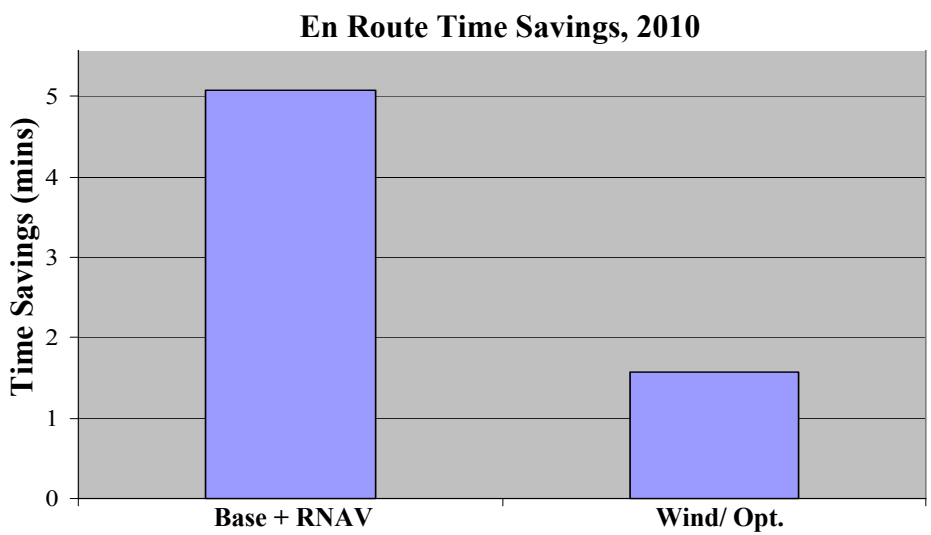
Average Airborne Time per Flight

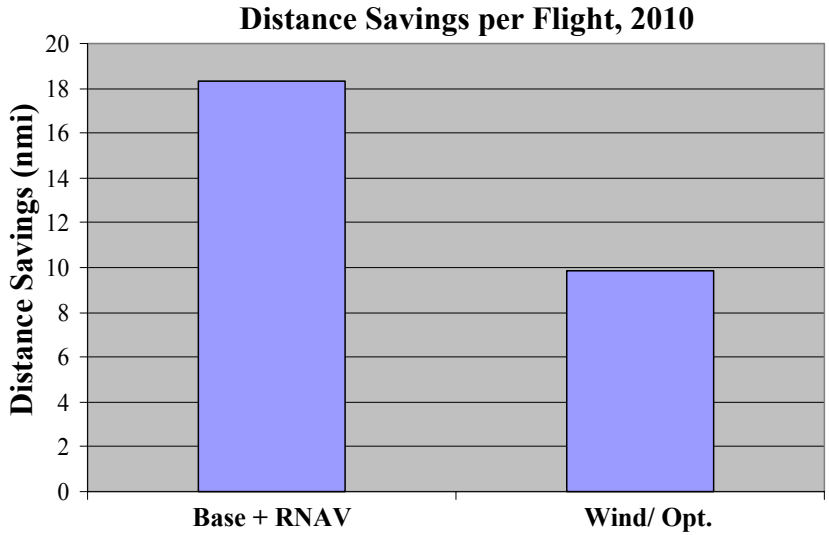


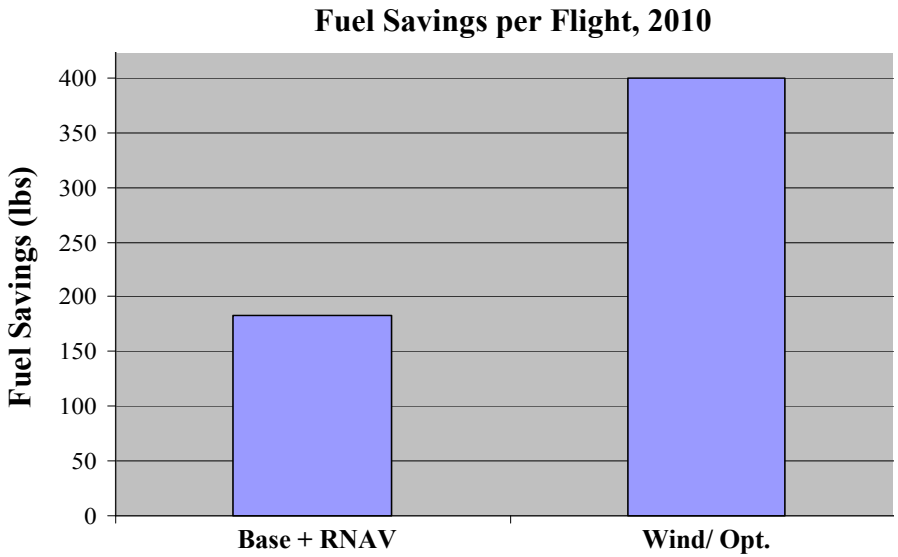
The airborne times in the Southern Region are slightly less than the rest of the NAS. The average airborne time for these flights in 2000 was 94.2 minutes; NAS-wide it was 101 minutes.

Results (Cont'd)

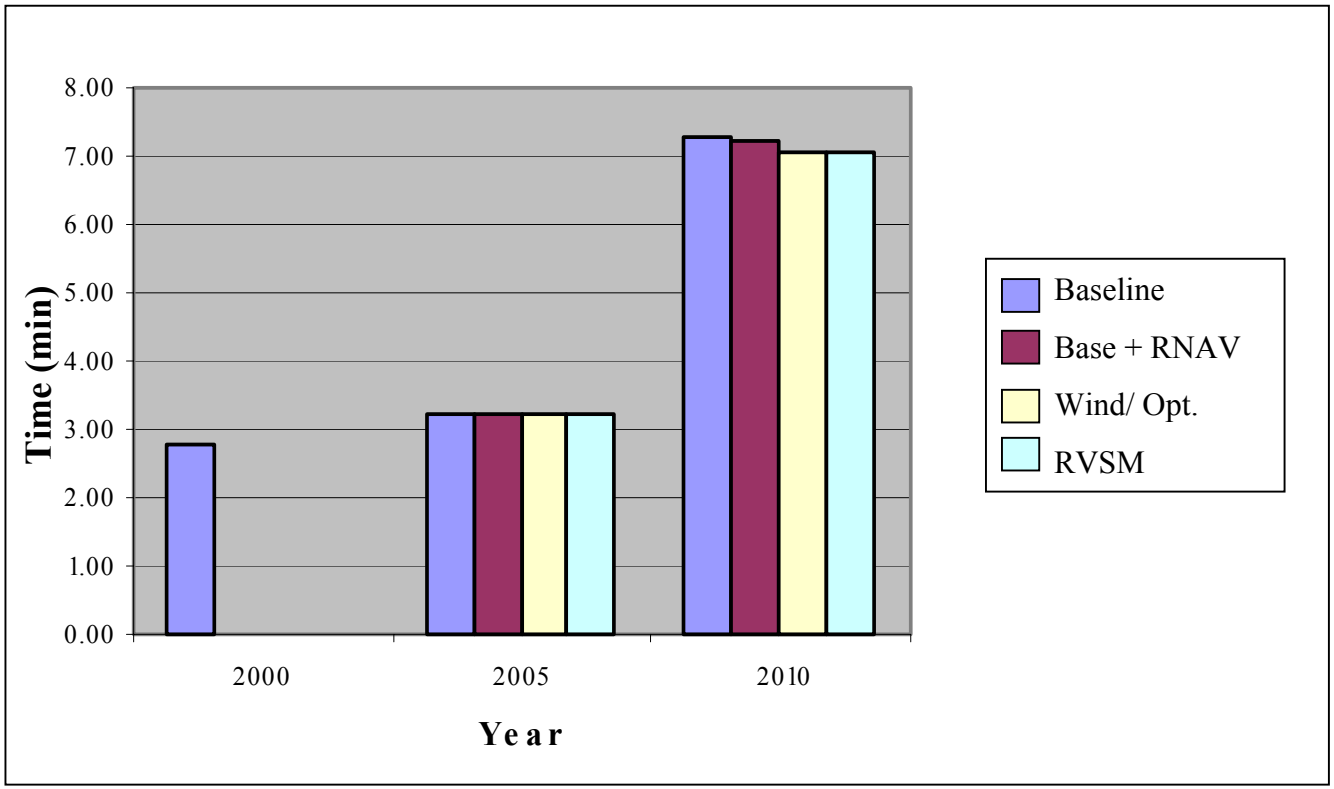
Marginal Savings Metrics per Incremental Flight





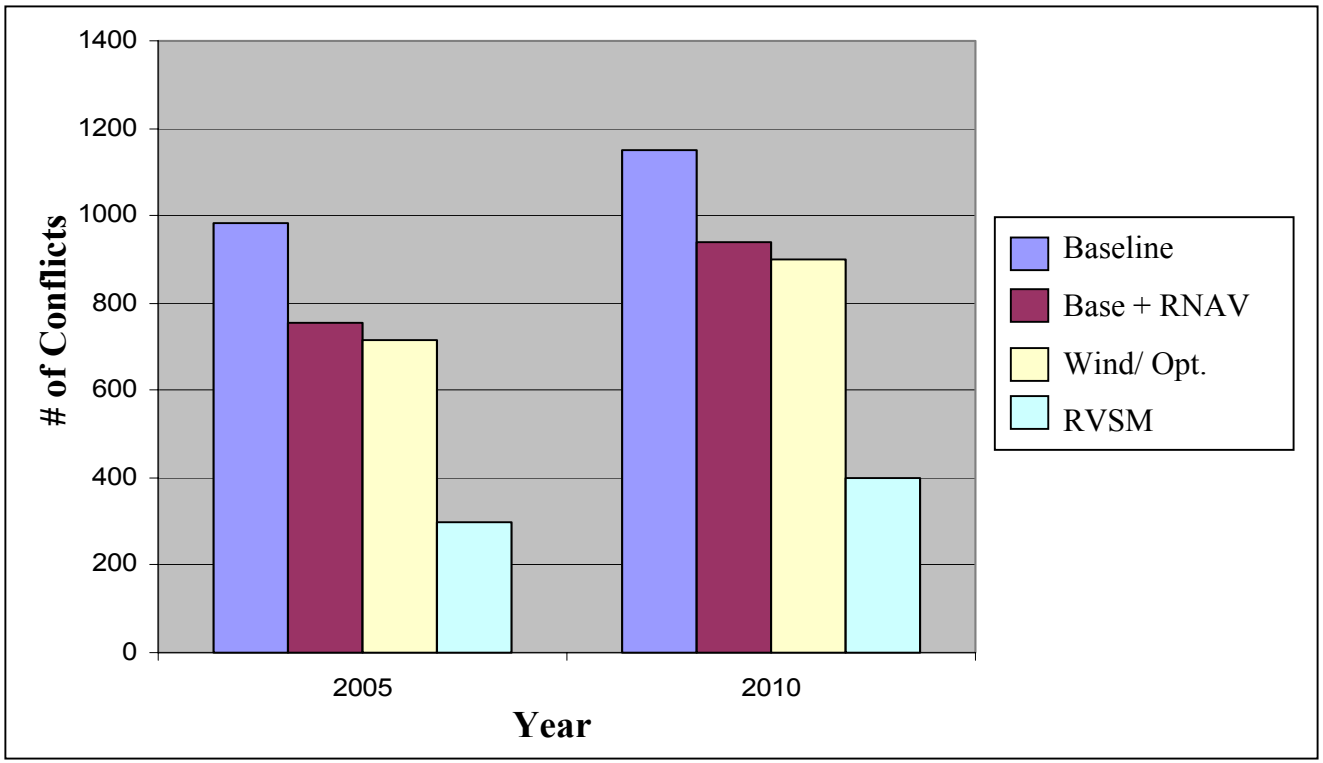


Results (Cont'd)
Operational Delay



The key element driving the longer delays in the out years is the higher ratio of demand-to-airport capacity

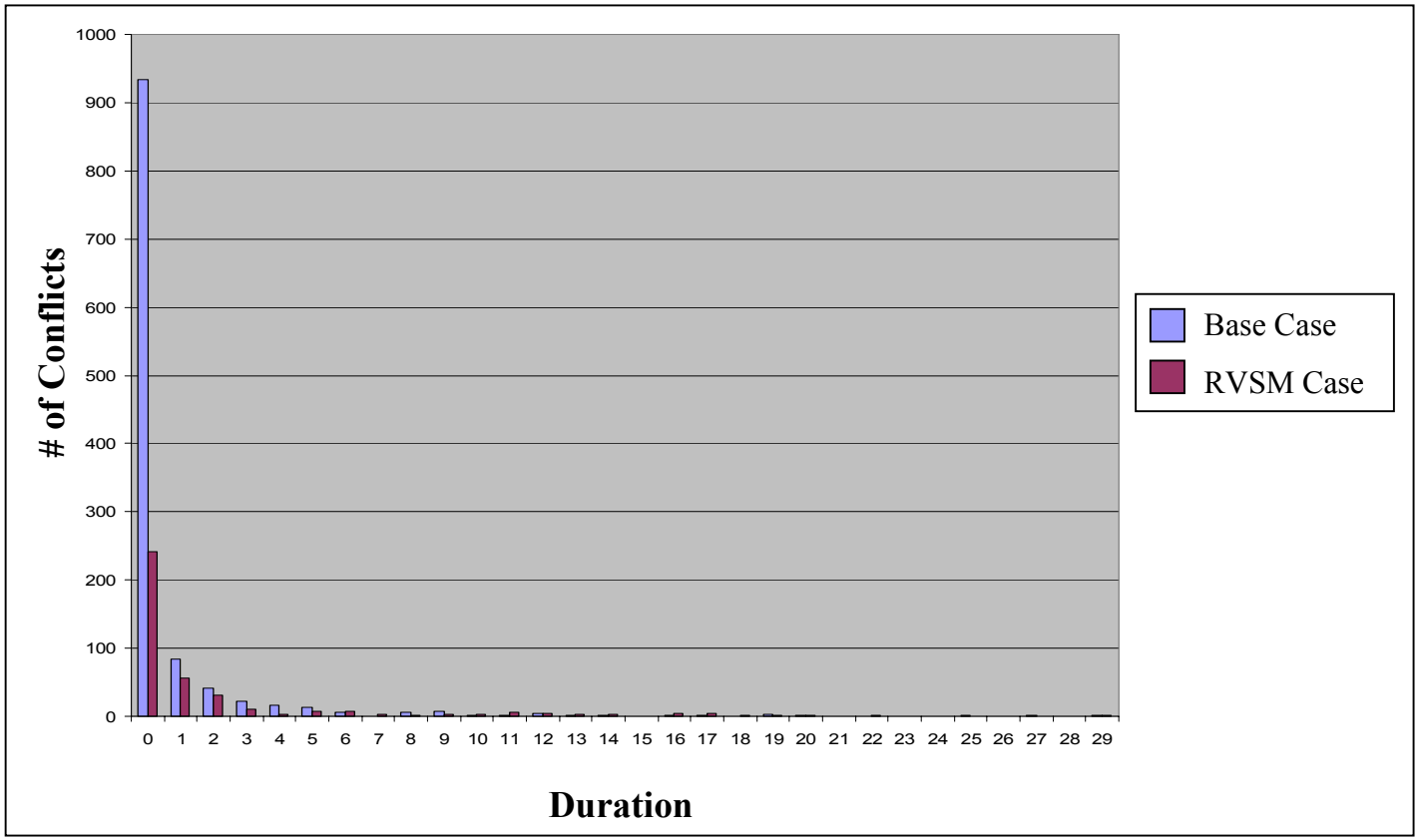
Results (Cont'd)
Number of Conflicts
(Flights FL290 or above through Southern Region)



Conflict is defined as a violation within 1000 feet vertically for RVSM case between FL290 and FL410 or 2000 feet vertically for non-RVSM case and a violation of 5 mile horizontal separation.

There were 5612 flights that flew at FL290 or above in 2005; 6058 flights in 2010

Conflicts
Distribution by Time
(Base Case 2010 vs. RVSM Case 2010)



Given a flight has a conflict, 81 percent of the 2010 base case have conflicts of <1 minute; 60 percent of the 2010 RVSM case have conflicts of <1 minute. This is a reduction from 950 conflicts to 250 conflicts.

Conclusions

- DRVSM shows great potential with reduction in conflicts
- Increased wind-optimized routing generates greatest benefits potential
- Maximum estimated total savings from baseline to all enhanced routing options by 2010
  - 1-1.5 percent (1.7M lbs. per day)
  - 53,000 nmi per day (4 miles per flight)
  - .85 minutes per flight
- The enhanced routing capabilities have minimal impact on operational delay
  - Need clearer understanding of enroute/terminal interactions
- Policy Question: ***How fast can increased direct routing be implemented?***

Backup Slides

Representative Fuelburn by Aircraft Type

(Cruise levels – lbs per min)

Type	FL290 (lbs/min)	FL310 (lbs/min)	Pct Savings (FL290 and FL310)	FL330 (lbs/min)	FL350 (lbs/min)	Pct Savings (FL330 and FL350)	FL370 (lbs/min)	FL390 (lbs/min)	Pct Savings (FL370 and FL390)
MD80	112.7	109.8	+2.5%	106.0	103.2	+2.7%	101.4	NR	-
B757	136.0	136.2	-0.2%	132.5	130.3	+1.7%	129.0	129.2	-0.2%
B737-6/7/8	122.6	122.6	0.0%	123.5	120.4	+2.5%	118.4	117.7	+0.6%
CARJ	45.4	42.5	+6.3%	39.9	37.7	+5.5%	36.2	34.8	+3.7%
B767	190.9	185.4	+2.9%	181.0	178.1	+1.6%	177.2	177.9	-0.4%
A300	219.4	213.4	+2.7%	207.7	203.7	+1.9%	201.9	202.4	-0.2%
DC9	120.6	114.0	+5.5%	108.2	103.2	+4.7%	NR	NR	-

Source: BADA

Sample of Flights in Southern Region
(NRP, RNAV, and ATC Pref)

Origin/Destination	Type of Route	Flight Distance	Airborne Time	# of Flights on 8/28/2000
ATL MIA	NRP/RNAV	505	83.6	12
ATL MIA	ATC Pref	550	84.2	8
ATL CLE	RNAV	483	81.8	12
ATL CLE	ATC Pref	495	82.8	6
FLL MCO	RNAV	160	35.5	8
FLL MCO	ATC Pref	165	36	
CLT JAX	NRP	295	49.0	6
CLT JAX	ATC Pref	315	51.0	1